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PRELIMINARY DISCUSSION OF CLIMATIC EFFECTS WHICH MAY ARISE FROM--ETC(U)

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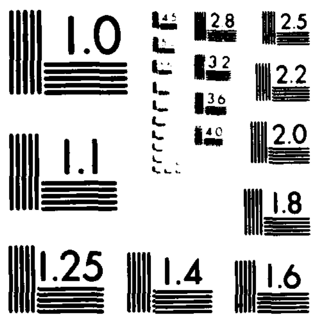

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PRELIMINARY DISCUSSION OF CLIMATIC EFFECTS WHICH MAY ARISE FROM THE DONGXIAN IRRIGATION PROJECT IN REROUTING WATER FROM SOUTH TO NORTH

by

Li Hongzhou, Zhen Zhangzhou, and Zeng Zhaomei

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PRELIMINARY DISCUSSION OF CLIMATIC EFFECTS WHICH MAY ARISE FROM THE DONGXIAN IRRIGATION PROJECT IN REROUTING WATER FROM SOUTH TO NORTH

by Li Hongzhou, Zhen Zhangzhou, and Zeng Zhaomei

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The largest water conservancy projects in our country are those which reroute water from the south to the north. Among them the Dongxian project has a maximum rate of flow of 1000 cubic meters per second, an area of irrigation of approximately 50,000 square kilometers, and an average amount of irrigation equal to a monthly precipitation of more than 50 mm. After the reservoir is regulated, it can be used in a fairly concentrated manner for the northern areas which have little rain in the spring, and is supposed to reach 100 mm per month. This is more than double the local natural precipitation. This surely will have an effect n the local climate. Not only has the Dongxian project already been started, but the first project, the Jiangdu irrigation and drainage pumping station, has already been completed. Therefore, it is quite essential that the climatic effects which may arise from irrigation be assessed.

Starting with available climatic data, we have analyzed the factors which affect sensible heat fields and obtained the possible effects of irrigation on sensible heat fields. We then proceeded to estimate the climatic effects which may arise.

I. THE MECHANISM GOVERNING CHANGES IN SENSIBLE HEAT FIELDS FOR THE DONGXIAN PROJECT

Let the sensible heat index

$$I_{sh} = V_a (T_s - T_a), \qquad (1)$$

where V_a is the monthly average surface wind velocity; T_s is the

monthly average surface temperature; and T_a is the monthly average air temperature at the surface.

1. The mechanism of annual change in sensible heat. Figure 1 is the annual change in insolation and sensible heat for two places, Qingjiang and Jinan. It can be seen that the general trend of changes for both places are the same. But the rainy season starts in July and sensible heat decreases more than insolation. In comparison to April which is dry, the insolation in July is clearly greater than April. But the sensible heat index is much higher for April than July. This indicates that the sensible heat index is not dependent merely on insolation. It is quite possible that high precipitation, which brings about high evaporation, causes the sensible heat index to drop.

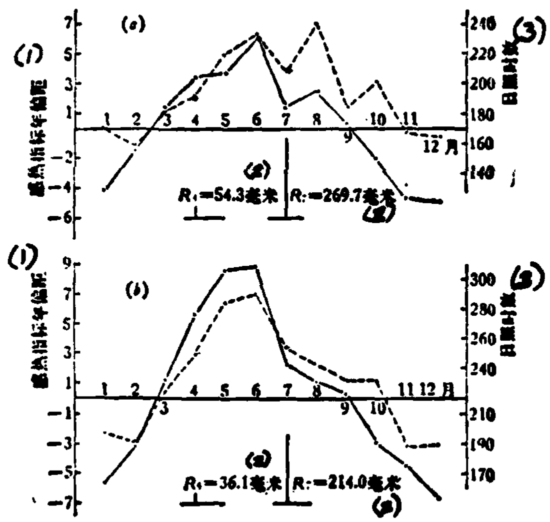

Fig. 1. Annual change in insolation (dotted line) and sensible heat (solid line)

(a) Qingjiang; (b) Jinan

KEY: (1) Annual deviation of sensible heat index; (2) mm; (3) number of hours of insolation

2. When it is dry the sensible heat index is higher than during the rainy season. Is this kind of phenomenon commom? Generally speaking, northern China is dry in the spring and the Changjiang (Yangtse) valley is hot and dry. We used the difference values of the sensible heat indices for July and April to make a distribution diagram (see Fig. 2). The universality of the mechanism mentioned above is clearly reflected in Figure 2.

Fig. 2. Distribution diagram of sensible heat index difference values for July and April

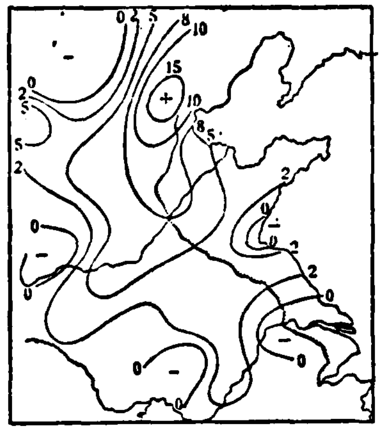

Fig. 3. Distribution diagram of sensible heat index difference values for April of dry years and years with plenty of rain in the spring in north China

3. After south to north water diversion has solved the dryness in spring in north China, will there be a drop in the sensible heat index in north China in April? Having selected a year when north China had a dry spring (1972) and a year with plenty of rain (1964), we used the sensible heat index difference values for April of these two years for the distribution diagram in Figure 3. The positive values for the index differences are centered in the region of Hebei and Shandong. This is the exact area which was the driest in the spring of 1972.

4. There is a relationship between frequent rain and hours of insolation. Below, under circumstances where the insolation conditions are roughly the same, we take a look at what kind of differences there are in the sensible heat indices for years with much rain and years with little rain.

Five stations along the south to north water diversion line were selected: Qingjiang, Jinan, Dezhou, Lunxian, and Tianjin. From among the April data for 27 years from 1951 to 1977, we selected years with approximately the same number of hours of insolation. Then from these we selected years with much rain (rainfall more than 30% above the 27 year average) as well as years with little rain

(rainfall more than 50% belowthe 27 year average). The results are shown in Table 1. From Table 1 it can be seen that in cases were insolation conditions are similar, the sensible heat index for years with much rain, as before, will be less than that for years with little rain. Evidently irrigation can cause the sensible heat index to decrease.

站名 (a)	1951—1977 平均雨量 (b) (mm)	(d) 多雨年				(g) 少雨年			
		雨量 (c) (mm)	I_{sh} (m°C/s)	日照 (e) (h)	样本年 (f)	雨量 (c) (mm)	I_{sh} (m°C/s)	日照 (e) (h)	样本年 (f)
(h) 天津	16.0	30.4	11.0	251.2	1956, 1957 1962, 1977	4.2	16.8	253.2	1968, 1971 1972, 1974
(j) 沧县	21.4	37.3	14.8	265.3	1962, 1965 1969, 1977	5.5	16.9	279.8	1960, 1966 1972, 1973
(k) 德州	26.8	44.1	9.0	257.9	1957, 1959 1968, 1977	9.8	11.6	259.9	1960, 1961 1972, 1974
(l) 济南	30.6	47.9	12.2	265.3	1959, 1962 1968, 1973	9.2	16.1	260.1	1955, 1960 1966, 1974
(m) 清江	65.1	123.2	7.9	233.0	1956, 1965 1974	24.0	13.0	233.1	1952, 1953 1955

Table 1. Certain average data for April

KEY: (a) Station name; (b) average precipitation; (c) rainfall (mm); (d) Years with much rain; (e) insolation (h); (f) sample years; (g) Years with little rain; (h) Tianjin; (j) Lunxian; (k) Dezhou; (l) Jinan; (m) Qingjiang

5. Now, beginning with the thermal equilibrium equation, based on the results of certain observations, experiments, and calculations we can estimate the changes which may occur in the amount of sensible heat transfer.

The thermal equilibrium equation for the surface can be expressed as:

$$R = LE + A + P \tag{2}$$

where R is the term for radiation equilibrium; LE is the term for evaporation; A is the term for downward conduction; and P is the term for sensible heat transfer.

Now, as before, Qingjiang and Jinan are used as examples. Yin Zongzhao [1] made calculations of the averages of R, LE, and P when there was no irrigation; A can be obtained on the basis of Equation (2)

calculations.

We presume that after the diversion of water from the south to the north, the amount of irrigation for April will be 100 mm per month. Budyko[8] has done experiments on the climatic effects of irrigation and when the amount of irrigation is 100 mm per month, R will increase 40%, but A basically will not change. We will apply this conclusion directly to Qingjiang and Jinan areas. Moreover, we presume that the irrigation water is all evaporated away through the plant leaf surfaces and the soil surface, and the increment of LE is easily determined; the value of P can easily be determined using Equation (2). The results are given in Table 2.

	(a) 清江		(b) 济南	
	(c)未灌溉	(d)灌溉后	(c)未灌溉	(d)灌溉后
R	6.1	8.54	5.5	7.7
LE	3.2	8.5	1.7	7.0
A	0.7	0.7	0.6	0.6
P	2.1	−0.66	3.2	0.1

Table 2. The effect of April irrigation equivalent to 100 mm of rainfall on the heat balance of the earth's surface

KEY: (a) Qingjiang; (b) Jinan; (c) When there was no irrigation; (d) After irrigation

From Table 2 it can be seen that irrigation causes the amount of sensible heat transfer P to drop to nearly zero.

II. THE CLIMATIC EFFECTS WHICH MAY ARISE FROM IRRIGATION

As before we can take a look, under approximately the same conditions of insolation, at certain climatic factors for years with much rain and years with little rain, such as what differences there are in monthly average temperature, ground temperature, absolute humidity, number of days of sandstorms, number of days of dust storms.

The results obtained are given in Table 3. The calculation conditions are exactly the same as Table 1, and this table can be considered as a continuation of Table 1. Table 3 is also an "average for five places", which represents an average for the area irrigated by the Dongxian project.

	(a) 多雨年						(b) 少雨年					
	(c) 雨量 (mm)	(d) 气温 (°C)	(e) 地温 (°C)	(f) 湿度 (mb)	(g) 扬沙 (日数)	(h) 浮尘 (日数)	(c) 雨量 (mm)	(d) 气温 (°C)	(e) 地温 (°C)	(f) 湿度 (mb)	(g) 扬沙 (日数)	(h) 浮尘 (日数)
(j) 天津	30.4	13.1	15.8	8.07	3.33	2.67	4.2	14.1	18.3	6.83	6.0	3.25
(k) 沧县	37.3	12.7	15.8	7.73	2.5	1.25	5.5	14.3	18.3	7.6	1.5	0.50
(m) 德州	44.1	14.6	16.9	8.33	3.25	0.50	9.8	14.8	17.3	7.23	6.0	1.00
(n) 济南	47.9	15.8	18.6	7.5	3.0	2.25	9.2	15.5	18.8	7.37	4.0	2.33
(p) 清江	123.2	13.5	15.2	—	—	—	24.0	13.9	16.8	—	—	—
(q) 五站平均	56.6	13.9	16.5	7.91	3.02	1.67	10.5	14.5	17.9	7.26	4.38	1.78

Table 3. Some other average data for April (Table 1 continued)

KEY: (a) Years with much rain; (b) Years with little rain; (c) rainfall (mm); (d) air temperature (^{o}C); (e) ground temperature (^{o}C); (f) humidity (mB); (g) sandstorms (no. of days); (h) dust storms (no of days); (j) Tianjin; (k) Lunxian; (m) Dezhou; (n) Jinan; (p) Qingjiang; (q) Five station average

We see by Table 3 that in the region irrigated by the Dongxian project when the rainfall for years with much rain is 46 mm greater than for years with little rain, the air temperature drops 0.6^{o}C, ground temperature drops 1.4^{o}C, absolute humidity rises 0.65 mB, the number of days of sandstorms decreases 1.4 days, and the number of days of dust storms decreases 0.11 days. When the amount of irrigation for a given month is 100 mm, the climatic effects which arise cannot simply be calculated on the basis of difference in the amount of rainfall, but we can estimate it roughly as twice the amount of the change mentioned above. Even when the amount of irrigation in April reaches 100 mm, it can cause the average temperature for that month to drop 1.2^{o}C, ground temperature to drop 2.8^{o}C, absolute humidity to increase 1.3 mB, the number of days of sandstorms to decrease 2.8 days, and the number of days of dust storms to decrease 0.2 days.

In the irrigation experiments in [2], when the amount of irrigation is 100 mm, the air temperature dropped 1^{o}C and absolute humidity

increased 1 mB. This is quite close to our estimates.

III. CONCLUSIONS

1. There will be a large decrease in sensible heat transfer for April in the area irrigated and a large increase in water vapor and the accompanying latent heat transfer. This will greatly change the local convection movements as well as the background conditions for convective precipitation. This problem merits further discussion.

2. The average air temperature for April in the irrigated area will probably drop 1.2°C which can cause a cumulative temperature drop in April of 36°C. This is approximately equal to the cumulative temperature for three days. And ground temperature will drop even more. This can have a corresponding effect on crops for which spring is the main growing season.

3. The entire south to north diversion project is mainly the transfer of water to the north due to the spring dry season in the north. After the entire project is completed, the area irrigated wil be about one-seventh of our country's present total cultivated land area. After spring irrigation, certain changes may occur in the physical properties of the underlying surface within the zone corresponding to the weather measurements. These can have somewhat of an effect on air-mass modifications. This is also a problem which requires further study.

We wish to express our gratitude to our two comrades, Ye Duzheng and Zhou Mingyu, for their enthusiastic support in the work on this paper.

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